

HUMAN FACTORS IN KEYPAD DESIGN

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ABSTRACT

A series of studies is reported in which a number of human factors considerations were investigated in the design of a keypad entry system for Telidon public access terminals. Initial studies evaluated subjects' preferences with simulated keypads upon which subjects performed simulated Telidon tasks. Subsequently, working prototypes were developed of the two most preferred keypads. User performance and preference were evaluated in a series of field studies. It was found that preference measures for the prototypes closely approximated data derived using the simulations, indicating validity of this inexpensive method of design testing.

Despite considerable research over the last twenty years, there remain a number of unanswered questions with respect to appropriate designs for keypads and keyboards. In part this is due to two factors. Firstly, despite their relative simplicity as devices, keypads and keyboards may be varied along a large number of different dimensions such as key arrangement, size, labels, colour, logic and mechanical features. Each of these dimensions may be manipulated across a large number of values resulting in an almost infinite variety of possible combinations. Secondly, though research may result in a close approximation to optimal design for a keypad with a specific function, the design is frequently function-specific and reassessment is necessary if a keypad is required to perform new functions.

The first problem is compounded by the practical consideration of hardware production. It is expensive and time-consuming to make, prepare and test large numbers of alternatives, particularly when a sophisticated link exists between the keypad and the controlled instrument.

Both of these problems were encountered in recent studies involving public access terminals for Telidon (Canada's Videotex system). A major current application for Telidon is as a public information system in such locations as shopping malls, hotel lobbies and airport lounges. The design of the keypad must accommodate the diverse levels of computer experience in the potential user group and be simple to use and learn. The research was stimulated by expressed dissatisfaction with the

current keypad in field trials (Dillon & Tombaugh, 1983; Francas, 1983). Major sources of concern were key size, layout of keys and the labelling system.

Examination of available evidence (e.g. Butterbaugh, 1982; Chapanis & Kincade, 1972; Conrad & Hull, 1968; Lutz & Chapanis, 1955; Norman & Fisher, 1982) revealed that, although many design criteria for full-size keyboards were well established, less information was available concerning keypads. Where specifications for keypads had been made (e.g. Hearty, 1982) the design centred on optimizing use with a hand-held, portable keypad, conditions which are not relevant to a public access terminal where size is less limited and portability is not an issue.

The research focussed on producing a keypad suitable for a public access terminal which would be simple for novice users to operate. Because of the large number of variables which could be manipulated in the design, it was decided that a two-phase experimental approach would be appropriate.

Following determination of the minimal subset of function keys, a variety of simulated keypads, produced as artistic life-size drawings, were tested. A process of elimination allowed the identification of the two keypads most favoured by subjects. The second phase of the experiment consisted of construction of these two keypads and their formal assessment in terms of subject preference and performance. This phase served not only to provide quantitative data upon which choice of the more appropriate keypad

could be made, but also served as a validation of the simulations performed in the first phase.

EXPERIMENTAL PHASE 1

Method Stage A

Instruments. Four simulated keypads were designed and drawn to scale in colour. The keypads varied in terms of arrangement of keys (linear or telephone) and colour combinations (red, green, blue and yellow). In these combinations, numeric keys were either a standard gray or were coloured and special function keys were either all of one colour or produced in two different colours. The keypads also varied in terms of the labels used for function keys (e.g. start vs. begin vs. hi vs. connect; finish vs. end vs. bye vs. disconnect; delete vs. erase vs. rub out; enter vs. go vs. return). Keys were either circular or square, the start/finish functions either appeared on one key or separate keys and the enter key location was varied.

A questionnaire completed after the experiment required subjects to rate the keypads in terms of each of the varied dimensions as well as providing for an overall rating and allowed open-ended opportunity for comment.

Procedure. Ten subjects drawn from the University community completed the experiment. All subjects completed a simulated Telidon search process on each keypad (e.g. What is the telephone number to call to obtain information on diabetes?).

They were introduced via instruction to the Telidon system and the simulation was explained. As each simulated key press was made a representation of the Telidon page was given to the subject. All problems and keypads were introduced in random order.

Results and Discussion

A narrow preference was shown for the telephone over the linear arrangement and a similarly narrow preference for a red/green/gray colour system. The preferred labels for function keys were start, finish, delete and enter. Square keys were preferred over circular, a combined start/finish key was preferred and location of the enter key was narrowly preferred at bottom right of the keypad.

On the basis of the firm preferences in this study some decisions were made for the next phase. The labelling system could be standardized with the labels shown above. Square keys were identified as appropriate and the combined start/finish key was selected. Ambiguity still existed, however, with respect to the colour preference, location of the enter key and, following comments on the open-ended section of the questionnaire, some consideration was thought necessary to the use of different sized keys for functions, particularly the enter key. These data therefore formed the basis of the next stage.

Method Stage B

Instruments. Four new simulated keypads were designed. Two were of the telephone type and two used a linear arrangement of keys. Location of enter keys was either top right, bottom right, top centre or bottom centre. Size was either x1, x2 or x3 regular key length. Colour combinations were varied and distinctiveness of certain keys (e.g. enter or start/finish) was enhanced by use of a separate colour. A questionnaire similar to that used in the first stage required subjects to evaluate both specific aspects of the keypads and to make general comparisons.

Procedure. The procedure used was identical to that in the first stage. All subjects were volunteers from a local shopping mall. Twelve subjects performed simulated Telidon tasks on both versions of the telephone-style keypad and 14 subjects performed the same tasks on two versions of the linear keypad. All subjects again received instruction on the nature of Telidon and the purpose of the simulation. Order of presentation of keypads and problems was counterbalanced across subjects.

Results and Discussion

A strong preference emerged in this study for the red/green/gray combination of colours. Specifically, regardless of keypad arrangement, it became clear that gray numeric keys, green function keys and red start/finish and enter keys represented an optimum combination. It was also found that a larger (x3 regular keys) key was preferred for "enter" and preferred location was bottom centre.

Method Stage C

Instruments. On the basis of these results two final designs were prepared. One was based on a linear arrangement and the other on a telephone-style arrangement. Otherwise they were identical. They both used the red/green/gray combination of colours with square keys, identical numerics and labels, separated and larger scale enter keys. The two keypads are illustrated in Figure 1.

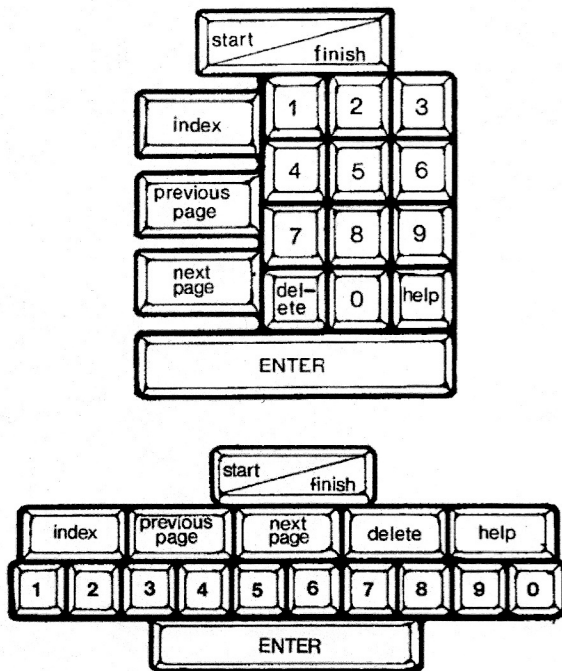


Figure 1. The design of the keypads.

Procedure. The procedure was similar to the other stages. A total of 38 naive subjects, who volunteered at a local shopping mall, completed two randomly presented simulated Telidon tasks on both keypads in counterbalanced order and completed the preference questionnaire. Subjects were also required to rate both keypads on a scale of ten. In addition subjects were asked to identify their degree of familiarity with computers, calculators and typewriters.

Results and Discussion

The overall preference ratings showed that 60% preferred the telephone arrangement whereas 40% of subjects preferred the linear arrangement. Average rating for the square keypad

was 6.8 and for the linear keypad was 6.1 out of ten on the rating scale. There were no significant differences in ratings between computer versus calculator versus typewriter experienced subjects.

The results of the open-ended questions as well as the quantitative measures of preference suggested that both keypads were generally satisfactory and that the manipulations made in the first two stages had resulted in appropriate choices of values along the design dimensions that had been manipulated. It was felt that the results were therefore sufficiently compelling to allow the development of a full experimental trial using working keypads and genuine Telidon problems rather than simulations.

EXPERIMENTAL PHASE 2

The second phase was divided into two separate components. Both were concerned with evaluation of the keypads constructed so as to conform with the simulations illustrated in Fig.1. All testing was conducted in a local shopping mall with users naive to the Telidon system. It was felt that should the preference of subjects using genuine versions of the keypads correspond closely with those in stage C of the first experimental phase, it would provide validation of the technique of simulation. At the same time quantitative performance measures available through the use of the keypads interfaced to the Telidon system would enable final selection of the keypad to be made on both performance and preference criteria.

Method Stage A

Instruments. The keypads were constructed conforming exactly with the simulated drawings. They could be interfaced directly to a Telidon terminal. Responses on the keypads could also be monitored in real time by an interfaced Apple II computer. A questionnaire sampling preference, rating of the keypads as well as identifying computer, calculator and/or typewriter expertise was also designed.

Procedure. Thirty-four volunteer subjects at a local shopping mall participated in this stage of the study. They read a standardized set of instructions and were shown how to sign on to the system. They were presented with four standardized problems for each keypad and order of keypad presentation was

controlled. Problems for each keypad were matched in terms of difficulty (number of key strokes to solution). Subjects were given a maximum of two minutes per problem. Each problem was typed on a separate card and, upon presentation to the subject, the experimenter typed a code on the terminal which activated the Apple computer data collection system. A similar code was typed when the subject verbally provided the answer to the problem, indicating termination of that problem. The next problem was then presented. After presentation of all problems subjects completed the preference questionnaire.

Results and Discussion

The results showed a clear preference for the telephone arrangement with 68% of subjects preferring this design compared with 32% preferring the linear arrangement. On the rating scale of ten, the mean value for the telephone design was 7.0 and 6.0 for the linear arrangement. The scores indicate a high degree of acceptance for both arrangements. In examination of the interaction between preference and previous experience with computers and typewriters or calculators, it was found that stronger preference for the telephone arrangement was shown by those with greater levels of experience.

Performance measures using the two keypads did not, however, reveal any significant differences. The number of problems solved, times to solution and number of errors were all similar for both keypads.

Stage B

It was considered that comparisons of performance using the different keypads in stage A were confounded by cognitive demands resulting from the organization of the particular Telidon data base used. It was therefore decided that a valuable second stage would be evaluation of performance in a single keypress search and locate task similar to a choice reaction time study. This information would serve to establish quantitative measures of search time with the two keypads. In addition, preference data could be acquired from subjects with a much briefer exposure to the keypads.

Method

Instruments. The same keypads were interfaced directly to the Apple II computer. A stimulus consisting of

either one of the numeric labels or a function key label was presented on the Apple screen. The computer was programmed to collect the time of keypresses following stimulus onset and to monitor errors. The same questionnaire was used as in stage A.

Procedure. Thirty-five subjects were tested using both keypads in balanced order. All subjects were volunteers from a local shopping mall. They were read a set of instructions concerning the task and completed 19 items per keypad, returning their hand to a predetermined starting point between trials. Subjects were required to respond as quickly and accurately as possible. They also completed the rating and preference questionnaire.

Results and Discussion

Preference data derived from these subjects showed that a slightly higher percentage (53%) preferred the linear keypad, whereas only 47% preferred the telephone arrangement.

The performance measures indicated slight superiority for the telephone arrangement. Mean total time for the 19 responses for this pad was 30.7sec. compared with 33.4 sec. with the linear keypad. The difference was not significant. Both keypads showed a very low error rate with a mean of .56 errors for the telephone and .64 errors with the linear arrangement. Mean performance was faster (but not significantly) on the telephone keypad, both for those who preferred this keypad and for those who preferred the linear keypad. It is worth noting that there was a trend towards slower individuals preferring the linear arrangement.

The low levels of errors in both conditions and the similarity of speed scores indicate that both keypads were effective and that the simulations had resulted in appropriate choices.

General Discussion

The practical result of this sequence of studies is collection of data concerning both preference and performance of typical potential users on two effective keypads suitable for public access terminals for the Telidon system. The methodological benefit of this sequence of studies is to provide a simple system for reducing the number of alternatives from a very large range to a manageable selection from which working prototypes can be manufactured.

The fact that results in the simulation stage C, in terms of preference, were identical to the combined preferences from stage A and B (60% vs. 40%) when using real keypads, indicates that there is a measure of validity in this form of simulation.

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